CLAIMS

We claim:

1. A battery comprising:

an anode;

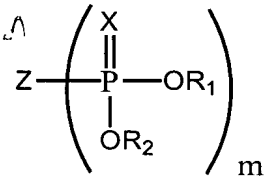
a cathode; and

an electrolyte having conductivity greater than about 10^{-3} S/cm at ambient temperature and which includes a compound that chemically interferes with flame propagation.

2. The battery of claim 1 wherein the compound that chemically interferes with flame propagation is a radical scavenger.

3. The battery of claim 1 wherein the compound that chemically interferes with flame propagation is fire damping.

4. The battery of claim 1 wherein the compound that chemically interferes with flame propagation comprises a compound having the general structure:



wherein X is oxygen or sulfur;

wherein R_1 is selected from the group consisting of (a) C_1 to C_{12} alkyl moieties that are terminally substituted with zero to three halogen atoms; (b) C_5 to C_7 aryl groups substituted with zero to four alkyl, haloalkyl, or alkoxy moieties; and (c) trialkylsilyl moieties, wherein the alkyl group has from about 1 to about 6 carbons;

wherein R_2 is selected from the group consisting of (a) C_1 to C_{12} alkyl moieties that are terminally substituted with zero to three halogen atoms; (b) C_5 to C_7 aryl groups substituted with zero to four alkyl, haloalkyl, or alkoxy moieties; and (c) trialkylsilyl moieties, wherein the alkyl group has from about 1 to about 6 carbons;

wherein Z is a moiety selected from the group consisting of (a) aryl, aralkylene, arylene, dialkylamino, diarylamino, alkylarylamino, trialkyleneamino, cyclic amino, cyclic amido, cyclic imido, or oxy derivatives thereof; and (b) trialkylalkyleneoxysilane, dialkyldialkyleneoxysilane, alkyltrialkyleneoxysilane, and tetraalkyleneoxysilane; and

wherein m is an integer from 1 to 4.

5. The battery of claim 4 wherein the aryl moiety is selected from the group consisting of: phenyl; 4-methylphenyl; 2,6-di-tert-butyl-4-methylphenyl; 2-tert-butyl-4-methoxyphenyl; 3-tert-butyl-4-methoxyphenyl, and 3-pyridyl.

6. The battery of claim 4 wherein the oxy derivative of the aryl moiety is selected from the group consisting of phenoxy and 2,6-di-tert-butyl-methylphenoxy.

7. The battery of claim 4 wherein the arylene moiety is selected from the group consisting of phenylene, pyridylene, trisubstituted benzene, trisubstituted pyridine, and trisubstituted triazine.

8. The battery of claim 4 wherein the aralkylene moiety is selected from the group consisting of 4-methylbenzyl; 4-methoxybenzyl; 1,4-dimethylenebenzene; and 1,3,5-trimethylenebenzene.

9. The battery of claim 4 wherein the dialkylamino moiety is selected from the group consisting of dimethylamino and diethylamino.

10. The battery of claim 4 wherein the alkylarylamino moiety is selected from the group consisting of methylphenylamino and ethylphenylamino.

11. The battery of claim 4 wherein the diarylamino moiety is selected from the group consisting of diphenylamino and bis(4-methylphenyl)amino.

12. The battery of claim 4 wherein the cyclic amino moiety is selected from the group consisting of pyridino, piperidino, pyrrolidino, and piperazino.

13. The battery of claim 4 wherein the cyclic imido moiety is selected from the group consisting of succinimidyl and glutarimidyl.

14. The battery of claim 4 wherein the oxy derivative of the cyclic imido moiety is O-succinimidyl.

15. The battery of claim 4 wherein the cyclic amido moiety is selected from the group consisting of 2-imidazolidinonyl, 2-pyrrolidinono, and 2-piperidinono.

16. The battery of claim 4 wherein the trialkyleneamino moiety is selected from the group consisting of trimethyleneamino and triethyleneamino.

17. The battery of claim 4 wherein the oxy derivative of the trialkyleneamino moiety is selected from the group consisting of trioxymethyleneamino and trioxyethyleneamino.

18. The battery of claim 4 wherein the dialkyldialkyleneoxysilane moiety is dimethyl-methyleneoxysilane.

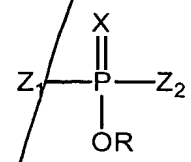
19. The battery of claim 4 wherein the tetraalkyleneoxysilane moiety is tetramethyleneoxysilane.

20. The battery of claim 4 wherein compound that chemically interferes with flame propagation is selected from the group consisting of: diethyl(2,6-di-tert-butyl-4-methylphenyl)phosphate; diethylphosphorosuccinimidate; diethylphenylthiophosphate; benzene-1,4-bis-diethylphosphate; triethanolamino-tris-diethylphosphate; diethyl-N-succinimidylphosphate; N,N'-bis(diethylphosphoro)imidazolidone; diethyl-3-pyridylphosphate; diethylphosphorodiphenylamidate; ethylphosphorodi-N-succinimidate; 1,4-bis(diethylphosphoro)benzene; and dimethyl-bis(diethylmethylphosphonatoxy)silane.

21. The battery of claim 4 wherein the halogen atom is fluorine.

22. The battery of claim 4 wherein the haloalkyl moiety is a fluoralkyl moiety.

23. The battery of claim 1 wherein the compound that chemically interferes with flame propagation has the general structure:



wherein X is oxygen or sulfur;

wherein R is selected from the group consisting of (a) C_1 to C_2 alkyl moieties that are terminally substituted with zero to three halogen atoms and (b) C_5 to C_7 aryl groups substituted with zero to four alkyl, haloalkyl, or alkoxy moieties;

wherein Z_1 is a moiety selected from the group consisting of aryl, aralkylene, dialkylamino, diarylamino, alkylarylamino, trialkyleneamino, cyclic amino, cyclic amido, cyclic imido, and oxy derivatives thereof; and

wherein Z_2 is a moiety selected from the group consisting of aryl, aralkylene, dialkylamino, diarylamino, alkylarylamino, trialkyleneamino, cyclic amino, cyclic amido, cyclic imido, and oxy derivatives thereof.

24. The battery of claim 23 wherein the Z_1 and Z_2 moieties are cyclic imido moieties.

25. The battery of claim 24 wherein the cyclic imido moieties are each succinimidyl.

26. A compound that chemically interferes with flame propagation selected from the group consisting of diethyl(2,6-di-tert-butyl-4-methylphenyl)phosphate; diethylphenylthiophosphate; triethanolamino-tris-diethylphosphate; diethyl-N-succinimidylphosphate; N,N'-bis(diethylphosphoro)imidazolidone; diethyl-3-pyridylphosphate; diethylphosphorodiphenylamidate; ethylphosphorodi-N-succinimidate; 1,4-bis(diethylphosphoro)benzene; and dimethyl-bis(diethylmethylphosphonatoxy)silane.

27. A flame-retarding electrolyte comprising:

an organic solvent; and

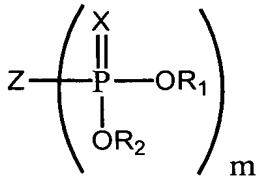
a thermal runaway inhibitor in the solvent;

characterized in that the electrolyte has a conductivity greater than about 10^{-3} S/cm at ambient temperature and the thermal runaway inhibitor chemically interferes with flame propagation.

28. The electrolyte of claim 27 wherein the thermal runaway inhibitor that chemically interferes with flame propagation is a radical scavenger.

29. The electrolyte of claim 27 wherein the compound that chemically interferes with flame propagation is fire damping.

30. The electrolyte of claim 27 wherein the thermal runaway inhibitor has the general chemical structure:



wherein X is oxygen or sulfur;

wherein R_1 is selected from the group consisting of (a) C_1 to C_{12} alkyl moieties that are terminally substituted with zero to three halogen atoms; (b) C_5 to C_7 aryl groups substituted with zero to four alkyl, haloalkyl, or alkoxy moieties; and (c) trialkylsilyl moieties, wherein the alkyl group has from about 1 to about 6 carbons;

wherein R_2 is selected from the group consisting of (a) C_1 to C_{12} alkyl moieties that are terminally substituted with zero to three halogen atoms; (b) C_5 to C_7 aryl groups substituted with zero to four alkyl, haloalkyl, or alkoxy moieties; and (c) trialkylsilyl moieties, wherein the alkyl group has from about 1 to about 6 carbons;

wherein Z is a moiety selected from the group consisting of (a) aryl, aralkylene, arylene, dialkylamino, diarylamino, alkylarylamino, trialkyleneamino, cyclic amino, cyclic amido, cyclic imido, or oxy derivatives thereof; and (b) trialkylalkyleneoxysilane, dialkyldialkyleneoxysilane, alkyltrialkyleneoxysilane, and tetraalkyleneoxysilane; and

wherein m is an integer from 1 to 4.

31. The electrolyte of claim 27 wherein the thermal runaway inhibitor is present in an amount greater than 0% to less than about 50% by weight of the solvent.

32. The electrolyte of claim 27 wherein the solvent is a blend of at least two organic solvents.

33. The electrolyte of claim 32 wherein the blend is comprised of ethylene carbonate and dimethyl carbonate.

34. A method for producing a thermal runaway inhibitor comprising the steps of:

providing a first starting material selected from the group consisting of 2,6-di-tert-butyl-4-methylphenol; phenol; triethanolamine; N-hydroxysuccinimide; 2-imidazolidone; 3-hydroxypyridine; diphenylamine, and succinimide;

mixing the starting material with a sufficient amount of an organic solvent in which the starting material is essentially soluble to form a solution;

mixing the solution with a base to form a first reaction mixture;

adjusting the temperature of the first reaction mixture to produce a first chemical reaction;

adding a second starting material selected from the group consisting of dialkylhalophosphate, dialkyl(chloromethyl)phosphonate, dialkylhalothiophosphate, and diarylhalophosphate to the first reaction mixture to form a second reaction mixture;

adjusting the temperature of the second reaction mixture to produce a second chemical reaction;

removing the organic solvent to produce a thermal runaway inhibitor.

35. The method of claim 34 wherein the dialkylhalophosphate is dialkylchlorophosphate.

36. The method of claim 34 wherein the dialkylhalothiophosphate is dialkylchlorothiophosphate.

37. The method of claim 34 wherein the diarylhalophosphate is diarylchlorophosphate.

38. The method of claim 34 wherein the thermal runaway inhibitor is selected from the group consisting of: diethyl(2,6-di-tert-butyl-4-methylphenyl)phosphate; diethylphenylthiophosphate; triethanolamino-tris-diethylphosphate; diethyl-N-succinimidylphosphate; N,N'-bis(diethylphosphoro)imidazolidone; diethyl-3-pyridylphosphate; diethylphosphorodiphenylamidate; and ethylphosphorodi-N-succinimidate.

39. A battery system comprising:

a first battery having a compound that chemically interferes with flame propagation;

a second battery having a compound that chemically interferes with flame propagation, wherein the second battery is operatively connected to the first battery.

40. A battery comprising:

an anode;

a cathode; and

an electrolyte having a maximum self-heating rate of less than about 0.350°C/min.